Development of a groundwater heating and cooling scheme in a Permo-Triassic sandstone aquifer in South-West England and approach to managing risks

D. Birks[1,3], C.A. Coutts[2], P.L. Younger[3] and G. Parkin[4]

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There are approximately 100 licensed groundwater heating and cooling applications in the UK, of which approximately 25% are installed in Permo-Triassic sandstone. The Permo-Triassic sandstones are extensively developed in the north of England, the midlands and to a smaller extent in the southwest, and are second only to the Chalk aquifer in terms of numbers of this type of application. In contrast to the Chalk, matrix flow is a more important component of the overall groundwater flow regime and, consequently, it is possible to predict groundwater behaviour with more confidence than for the Chalk and other aquifers with fracture-dominated flow. This equates to less uncertainty and is a significant consideration in regard to managing the overall risk-investment profile for this type of development. Development of an open-loop groundwater system to provide an estimated 871,000 kWh heating and 1,003,250 kWh cooling per annum, respectively for a proposed custody centre at Devon and Cornwall Police HQ in Exeter highlights the potential deployment of the technology in a relatively small fault bounded block of Permo-Triassic sandstone in South-West England. Development started in 2010 with an initial hydrogeological assessment and through 2012 an exploration well was constructed and subsequently tested for both abstraction and injection. Notwithstanding that the scheme is not yet fully developed, it is now licensed and the project serves as a good example of how the risk investment profile for similar projects might be managed. In addition, it highlights some specific properties of Permo-Triassic sandstones considered by the authors to be more favourable than other aquifers, including the Chalk.

[1] WSP | Parsons Brinckerhoff, Kings Orchard, 1 Queen Street, Bristol, BS2 0HQ, U.K.
[2] WSP | Parsons Brinckerhoff, WSP House, 70 Chancery Lane, London, WC2A 1AF, U.K.
[3] School of Engineering, James Watt Building (South), University of Glasgow, Glasgow G12 8QQ, U.K.
[4] School of Civil Engineering & Geosciences, Newcastle University, Newcastle upon Tyne NE1 7RU, U.K.
(E-mail: BirksD@pbworld.com)

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Introduction

The UK building stock is required to reduce its environmental impact and designers and engineers are obliged to consider ways of achieving this. Groundwater sourced heating and cooling is one of a number of low carbon technologies that has attracted an increasing level of interest in response to legislative and economic drivers (Clarkson *et al.* 2009; Younger, 2008).

Open-loop groundwater heating and cooling systems operate on the premise of extracting groundwater and pumping it through a heat pump or heat exchanger. Heat is transferred to or from the pumped groundwater providing heating and or cooling. Until recently the effluent water from these types of operations was typically disposed to surface watercourses. In the last 10 years, however, as the number of this type of application has increased significantly there has been an increasing requirement to return the effluent water to the originating aquifers.

Groundwater has proven to be a highly efficient means of heating and cooling, with coefficients of performance (COP) of 3-4 for heating and 4 to >10 for cooling commonly reported (e.g. Banks, 2012). Furthermore, unlike other low carbon heating and cooling options (i.e. solar, biomass), most of the infrastructure is located below ground such that the building aesthetic and valuable occupancy space is maintained. Demands on occupancy space are reduced further by the increasing use of plate heat exchangers in some of the larger applications of this technology (e.g. this development at Exeter, the Tate Modern, the Royal Festival Hall, Green Park Underground Station) where the requirement for large water storage vessels is negated. For these and other reasons groundwater is an attractive option for architects and the building services designer.

In the last 10 years the use of shallow groundwater for space heating and cooling utilising heat pumps has increased. However, in spite of this interest, development and commercial deployment of this technology has been limited. For example, the Environment Agency database (December 2014) had records of just over 100 licensed systems in England; the majority of these for commercial buildings including offices, retail space and public buildings. The Environment Agency database does not specify heating/cooling capacities but it is reasonable to conclude heating and cooling capacities of